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FOREST SERVICE

This report is from the
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Yellow-Poplar Responds To Preplanting Ground Treatment

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Various species of pine are used for most of the old-field plantings in the Central Hardwood Region. Some of the old fields planted to conifers are perhaps suited to hardwoods also, but because of the lack of experience and technical know-how, landowners are often reluctant to plant them on these sites. Recent experiments in Ohio reveal that ground-preparation treatments may have an important effect on the growth of hardwoods planted on old fields.

As a step toward finding better ways to establish hardwood plantations, we began a study in 1949 on a typical old field in southeastern Ohio to observe how five different ground preparations affected the survival and growth of yellow-poplar (Liriodendron tulipifera L.) planted by three different methods. Because planting costs are increasing, the value of preplanting ground treatments must be examined critically to determine whether the benefits derived are worth the extra time and money spent. The preliminary results of this study are summarized here. A similar study is underway for white pine and red pine.

Previous research in other regions has led to the general conclusion that preplanting ground treatments help in establishing certain trees (1, 9, 10, 14, 15). However, most workers seem to agree that site quality, drainage, and intensity of plant competition definitely influence the value of such treatments. In addition, planting method sometimes affects survival and growth. For example, poor survival in some red pine (Pinus resinosa Ait.) and jack pine (P. banksiana Lamb.) plantations has been attributed to the fact that bar planting cramps the roots into a single plane retarding growth for many years (7).

WHAT WE DID

THE TEST SITE WAS A TYPICAL OLD FIELD

Planting was done on a typical old field made available for this study by the Ohio Power Company. The soil type is Muskingum silt loam, one of the most widespread soil types in southeastern Ohio. The surface soil on the study area is generally shallow. Subsoils vary from clays to silty-clay loams. Evidently the planting site was once pastured, but it had not been used for several years.

The vegetational cover was typical of abandoned pastureland in southeastern Ohio. Some sassafras (Sassafras albidum (Nutt.) Nees) and dogwood (Cornus florida L.) occurred, as well as a few patches of blackberry (Rubus sp.).

The study is comprised of three blocks, each 380 feet long and 198 feet wide. One block has a northwest aspect, the second has an east aspect, and the third is almost level but slopes slightly the the southwest. There are 5 plots or 15 subplots in each block with a total of 15 plots or 45 subplots in the three blocks.

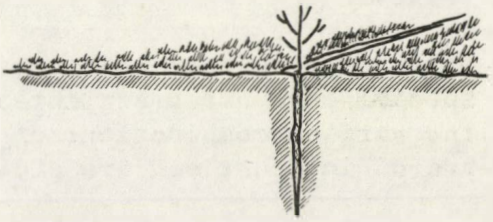
FIVE GROUND PREPARATIONS WERE TESTED

The five methods of ground preparation we used were:

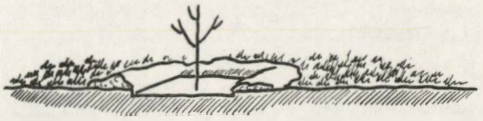
1. Double furrows.--Made with a two-bottom plow. Trees were planted on the "lay" of the double furrow.

2. Single furrows.--Plowed with a single-bottom plow. Trees were planted in the bottoms of the furrows.

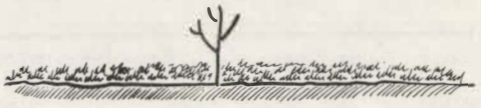
3. Rips.--Made to a maximum depth of 28 inches to loosen the subsoil. Trees were planted in the rips.



4. Scalps.--A 2-foot square of sod was removed with a mattock where each tree was to be planted.



5. No preparation.--One plot in each block was not treated before planting and served as a check.



Furrowing was done parallel to the contours using ordinary farm equipment. All furrows were thrown downhill. Ripping was done with a heavy shale ripper drawn by a large crawler tractor. Because of the long turning radius needed, we had to do the ripping at right angles to the contours. All ground preparations were completed in the fall previous to the planting.

THREE PLANTING METHODS WERE USED

We used three planting methods: (1) bar planting, (2) mattock planting, and (3) machine planting. All the hand planting was done by men who had some prior planting experience. Machine planting was done by two members of the Muskingum Conservancy planting unit who had several years experience planting under similar conditions.

All planting was completed in the spring of 1949. We planted 25 yellow-poplars and 85 black locusts (Robinia pseudoacacia L.) in each subplot so that each yellow-poplar was surrounded by four black locusts. Using another species as a cover to create conditions more favorable for establishing certain hardwoods is now common practice. Chapman (2) and others (3, 4, 5) have found black locust to be one of the best of the "nurse" trees.

The spacing used in the planting was 6 by 6 feet. The yellow-poplar tops averaged about 0.6 feet in length; the roots were slightly longer.

Although planting costs were abnormally high because of the special care necessary in experimental work, the relative costs of the various combinations of ground preparations and planting methods are of interest and are shown in table 1.

Table 1.--Relative cost of 15 combinations of site treatment and planting methods[1/]

Planting method	Site preparation				
	None	Double Furrows	Single Furrows	Rips	Scalps
Machine	1.0	1.4	1.4	1.7	1.9
Bar	1.6	2.1	2.2	2.5	2.8
Mattock	2.3	2.9	2.5	2.8	3.8

1/ Each ratio based on the average cost of planting three subplots.

SURFACE SOIL DEPTH MAPS WERE MADE

When large experimental blocks are used, as in this study, it is difficult to avoid soil differences between plots as well as between subplots. This was foreseen so a surface soil depth map was made of the blocks before the ground preparation was done.

FOLIAGE ANALYSES WERE MADE

In the years 1949, 1951, and 1954, we collected mature leaves from the yellow-poplar trees, keeping the leaf collections separate by plots within blocks. The leaf samples were air dried, ground in a Wiley mill, and then ovendried at 70° C.

Leaves for each of the 3 years were analyzed for total nitrogen content using an accepted modification of the Kjeldahl method (6).

SOIL MOISTURE WAS STUDIED

The survival and early growth of planted trees are often greatly affected by the supplies of moisture in the soil. It appeared probable that the site treatments under test here might affect soil moisture, so we took samples during the first 3 years after planting to determine moisture content of the soils within the three blocks. Care was taken to take samples from each plot where the soil had been affected by the treatment. Samples from the surface soil and the subsoil were taken midway between planted trees in the lower slope, middle slope, and upper slope portion of each plot. These three samples were consolidated into one surface soil and one subsoil sample for each plot, or treatment, in each block. Sampling was done at approximately 1-month intervals, but the number of samples was not the same each year. Three were taken in 1949, four in 1950, and five in 1951.

The soil moisture data were averaged by years and site preparations for the two soil horizons sampled.

WHAT WE FOUND OUT

SURVIVAL WAS NOT AFFECTED BY TREATMENTS

There was no significant difference in the survival rates of the yellow-poplar among treatments (table 2). The overall survival after 5 years was 91 percent. Trees planted in scalps had the lowest survival (85 percent); those planted in single furrows had the highest survival (95 percent).

After 5 years, no real difference in survival between planting methods was found. Survival for machine-planted trees was 93 percent; for mattock-planted trees, 91 percent; and for bar-planted trees, 89 percent.

Because the black locust trees serve only as a temporary cover for the poplars, data were not taken on the survival and growth of this species. But it is estimated that more than 95 percent of the locust survived after 5 years.

In 1954, the sixth year, the tops of a large number of the yellow-poplars in one of the blocks died. However, most of these trees sprouted from the root collar in the same year on in 1955, so the percent of living trees has been maintained at a comparatively high level.

Table 2.--Percent of yellow-poplar survival after 5 years by site preparation treatments and methods of planting

Planting method	Site preparation					Method average
	None	Double furrows	Single furrows	Rips	Scalps	
Bar	85	87	97	91	83	89
Mattock	92	91	96	97	77	91
Machine	95	95	91	91	96	93
Average	91	91	95	93	85	91

HEIGHT GROWTH WAS INFLUENCED BY SOIL DEPTH

All growth data analyses presented here are based on 5-year results. The height measurements for 1954 (sixth-year data) include many trees that sprouted and are thus not suitable for analyses.

Growth data were first examined without regard for differences in soil depth between plots (table 3). On this basis, an analysis of variance (8) showed significant differences between ground preparations but not between blocks or planting methods.

Table 3.--Heights of yellow-poplar after 5 years by site treatment and planting method

(In feet)

Planting method	Site preparation					Method average
	None	Double furrows	Single furrows	Rips	Scalps	
Bar	2.3	4.0	3.1	3.0	2.3	3.0
Mattock	2.2	4.5	4.0	2.8	2.4	3.2
Machine	3.7	4.8	3.4	3.6	2.7	3.7
Average	2.8	4.4	3.5	3.1	2.5	3.3

Then, by pairing height-growth (table 3) and soil-depth data (table 4) and making an analysis of covariance, we found that there was a significant correlation between tree height and soil depth. After adjusting tree heights for soil depth, the differences in heights among treatments in some cases became greater (table 5). Moreover, if we ignore differences in soil depth, it can be seen that preparing the ground by ripping resulted in faster growth than where there was no preparation. But when we correct heights for soil-depth differences, this situation is reversed and we find that ripping actually slowed down height growth. When tree heights are corrected for soil depth, differences among planting methods become greater.

Table 4.--Average surface soil depth by site preparations and planting methods

(In inches)

Planting method	Site preparation					Method average
	None	Double furrows	Single furrows	Rips	Scalps	
Bar	3.8	6.3	5.7	6.8	5.8	5.7
Mattock	4.7	4.8	6.5	6.2	5.3	5.5
Machine	5.5	5.7	4.7	5.5	5.3	5.3
Average	4.7	5.6	5.6	6.2	5.5	5.5

Table 5.--Average measured tree heights and tree heights corrected for soil depth by ground preparation and planting method

(In feet)

Ground preparation and planting method	Average measured height	Height after correction for soil depth
Double furrow	4.4	4.4
Single furrow	3.5	3.4
Rips	3.1	2.8
No-preparation	2.8	3.2
Scalps	2.5	2.5
Machine	3.7	3.8
Mattock	3.2	3.2
Bar	3.0	2.8

HEIGHT GROWTH WAS ALSO INFLUENCED BY GROUND PREPARATIONS

The last step was to isolate the net effect the various ground treatments had on the height growth of the trees. We did this by determining the relationship of tree height to soil depth in the nine no-preparation plots (fig. 1). The resulting regression equation was used to compute the heights that trees on the treated plots would have attained had there been no ground preparation (table 6).

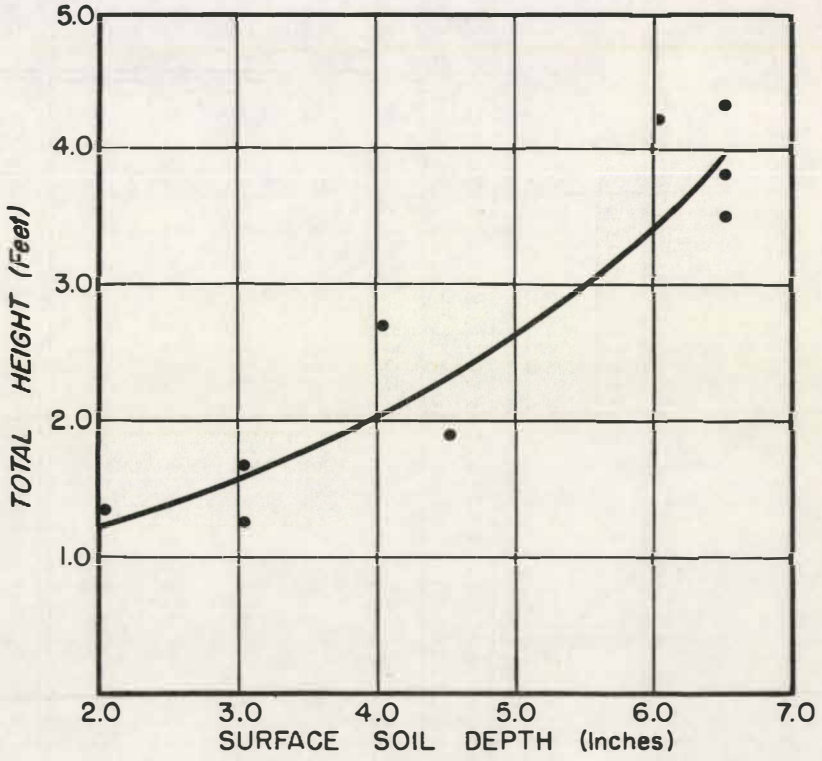


Figure 1.--Relationship of height of yellow-poplar in no-preparation plots with surface soil depth in these plots.

The trees in double furrows averaged 38 percent taller than they would have with no preparation; and this difference was found to be highly significant. While the actual tree heights in single furrows also appeared greater than estimated heights, and the trees in rips and scalps appeared to have been retarded by treatment, these differences were not significant (table 6).

Table 6.--Estimate[1] of effect of ground preparation on height growth of yellow-poplar after 5 years

Preparation	Machine		Bar		Mattock		Mean			
	Estim. height	Actual height	Estim. height	Actual height	Estim. height	Actual height	Estim. height	Actual height	Difference	
	feet	feet	feet	feet	feet	feet	feet	feet	feet	percent
Double furrow	3.2	4.8	3.8	4.0	2.7	4.5	3.2	4.4	+1.2	+38
Single furrow	2.7	3.4	3.3	3.1	4.0	4.0	3.3	3.5	+0.2	+ 6
Rips	3.3	3.6	4.4	3.0	4.5	2.8	4.1	3.1	-1.0	-24
Scalps	3.1	2.7	3.4	2.3	3.3	2.4	3.3	2.5	-0.8	-24
Mean	3.1	3.6	3.7	3.1	3.6	3.4	3.5	3.4		
Difference	+0.5		-0.6		-0.2				-0.1	
Percent	+16		-16		-6					- 3

[1] Estimated heights are computed from the equation which was derived from the height data in the plots having no preparation and which is taken as indicative of the height growth response by yellow-poplar to changes in surface-soil depth for the experimental area. Plus percentages indicate height growth over that expected with an apparent positive effect of ground preparation; negative percentages indicate height growth less than expected with an apparent negative effect of ground preparation.

LEAVES ON DOUBLE-FURROW PLOTS HAD HIGHEST NITROGEN CONTENT

We went to our foliage analysis data hoping to find an explanation for some of the growth responses to site treatment.

The results of these analyses are given in table 7. The nitrogen content of the leaves taken from trees in the double furrows appears to be higher than in other treatments. Statistical analyses of these data showed this apparent difference to be of real significance both in 1949 and in 1951. In 1954, there were no longer any real differences in foliar nitrogen content between treatments.

It is of interest also that the foliar nitrogen level for the entire study has increased from 1949 and 1951 to 1954. It was during this period that the crowns of the black locust trees formed a closed canopy on many of the plots. Possibly the root systems of the black locust trees have overlapped in these plots also, supplying nitrogen associated with the nodules on the roots to the yellow-poplar roots.

Table 7.--Percent of nitrogen in yellow-poplar foliage by site treatments for 3 years

Year	Site preparation					Method
	None	Double furrows	Single furrows	Rips	Scalps	
1949	1.42	1.58	1.33	1.37	1.34	1.41
1951	1.40	1.51	1.41	1.33	1.28	1.39
1954	1.73	1.84	1.68	1.77	1.57	1.72

RESULTS OF SOIL MOISTURE STUDY

The moisture levels in the double-furrowed plots are consistently lower than in the other treatments (table 8). However, the differences between the moisture level in the double furrows and the mean of the four treatments decreased progressively from 1949 to 1951.

It was not practicable to maintain gauges to correlate rainfall with soil moisture in this study. The average of three Weather Bureau stations within a 20-mile radius of the study area shows that rainfall in 1949 in this general area was about 2 inches below normal; in 1950 it was more than 5 inches greater than normal; and in 1951 it was about 2 inches greater than normal (11, 12, 13). The yearly averages of the moisture percent found in the surface soils reflect this rainfall pattern.

The drier conditions found in the double furrows may be due to their "perched" condition permitting greater evaporation. This is borne out by the fact that the difference was greatest in the first year and decreased as the mounded earth eroded and vegetation became established.

Statistical analyses of the data in table 8 show that the soil in the double furrows is significantly drier than in the other treatments. Although a casual examination of the data would indicate that the surface soils of the single furrows had a higher moisture content for all 3 years, the moisture levels in this treatment were not significantly higher. However, there is an indication at least that the furrows served to trap enough water to keep the soil slightly wetter than in the other treatments. It is also possible that the monthly sampling did not reveal higher levels of moisture that may have occurred for short periods following precipitation.

The subsoil of the ripped treatment was somewhat wetter than the subsoil of the other treatments during all 3 years. This is probably because the loosening effect of the ripping in the heavy subsoil permitted water to infiltrate more readily.

Table 8.--Soil moisture percent by soil horizons by years for the five ground preparations

SURFACE SOIL

Year	Ground preparation treatment: No preparation	Scalps	Single furrows	Double furrows	Rips	Yearly average
1949[1/]	16.8	17.1	17.3	11.9	16.5	15.9
1950[2/]	22.7	22.0	24.0	20.0	22.0	22.1
1951[3/]	16.4	16.8	17.2	15.8	17.0	16.6
Average	18.6	18.6	19.5	15.9	18.5	18.2

SUBSOIL

1949	19.0	18.5	17.9	13.9	22.3	18.3
1950	20.4	20.7	22.9	18.9	23.6	21.3
1951	16.4	16.1	16.7	15.9	18.5	16.7
Average	18.6	18.4	19.2	16.2	21.5	18.8

SURFACE SOIL AND SUBSOIL

1949 - 1951 average	18.6	18.5	19.4	16.0	20.0	18.5

1/ Based on average of three monthly samples.
2/ Based on average of four monthly samples.
3/ Based on average of five monthly samples.

WHAT IT MEANS

Apparently yellow-poplar seedlings respond in height growth with changes in soil depth. Consideration of soil depth as a variable affecting growth has revealed some facts in this study that might otherwise have been obscured. Furthermore, if soil depth had not been regarded, and if, by chance, soil depth had been confounded with the experimental design the results might have been completely misleading.

The fact that survival rates are high and have no consistent relationship with ground preparation and planting method is of interest. During the years since this study was established, there have been both favorable and unfavorable growing seasons, but none of the effects of treatment has appeared to be correlated with weather conditions as far as survival is concerned. It is of particular interest that machine planting, the cheapest method tested, has resulted in better than average survival throughout at least the first 5 years.

We cannot completely explain at this time why the trees planted on the lay of the double furrows grew faster than the others. From our foliage analysis data, it appears that the trees in this preparation had available nitrogen in greater supply than trees in the other site treatments -- at least during the first few years after planting. Perhaps the fact that the surface-soil depth was artifically increased where the trees were planted in the double-furrow treatment had something to do with the increased supply of nitrogen. The layer of organic matter that was covered in furrowing may have made the soil around the roots of the seedlings more fertile. It is also possible that there may have been better aeration in the mounded surface soils of the double furrows.

However, if these conditions increased height growth rate of trees planted in the double furrows, lack of these conditions might be expected to have had the opposite effect on height growth of trees planted in the bottom of the single furrows. For here the surface soil was made shallower, and little or no organic matter remained. On the other hand, the single furrows may have served as catchment basins for water, temporarily increasing the moisture supply to the trees. This might have compensated to some extent for the less than average depth of surface soil in the furrows. As was pointed out, the samples taken to investigate soil moisture were not taken often enough to reveal temporary increases in soil moisture.

The lower moisture level found in the double furrows apparently was not critical for tree growth as is evidenced by the growth attained in this preparation. In fact, the good growth associated with this preparation may partially explain why the moisture level is lower. Because the trees here have made better growth, it is reasonable to suppose that they have better developed root systems and thus draw more heavily on the available moisture.

Ripping and scalping did not benefit height growth. Ripping, temporarily at least, broke up a rather tight subsoil and we expected that root penetration and percolation of moisture would be improved on these subplots. Although there are indications that there has been some improvement in moisture percolation into the subsoil, it has not been reflected in the growth rate of the trees. However, beneficial results of this treatment may become evident as the trees grow older.

Scalping removed the organic matter and root mat from the spot the tree was planted. But, unlike the single furrows, the scalps were probably of little value as catch basins for water. At least there is no indication of this in the soil moisture data. And the lack of organic material and a catch basin on the soil surface may have caused the soils to dry out rapidly, reducing the moisture available to the trees. No other reasons can be given at this time for the poor growth of the trees in this treatment.

The important evaluation of the site treatments is summarized in table 6. The basis for this evaluation is the assumption that the heights of the trees in the nine no-preparation subplots represent the heights that could be expected in all the subplots had there been no preparation before ground treatments were installed. It is believed that this is a valid assumption because all blocks are equally represented and the assignment of no preparation, as well as treatments, was made randomly within blocks. Trees in the double furrows are estimated to be 38 percent taller than they would have been had there been no preparation in these plots. In table 1 it can be seen that machine planting in double furrows cost 40 percent more than the cheapest combination, machine planting with no preparation. Is the 40 percent additional planting cost offset by the 38 percent additional growth evident after 5 years? This question, of course, cannot be answered until the planting is old enough for yields to be compared. It is certainly very possible that if a growth advantage persists with the double-furrow trees, the additional planting cost may sometimes be a worthwhile investment.

We plan to make a pilot-plant test, planting yellow-poplar alternately in double furrows and with no preparation to test the experimental results reported here under normal, large-scale planting conditions.

SUMMARY

The effects of ground preparation and planting method on survival and growth of yellow-poplar were tested. Five different ground preparations and three different planting methods were used.

After adjusting the heights of the trees for soil depths that differed among plots, significant differences in height were found among ground treatments and planting methods.

Foliage analyses showed there apparently was more available nitrogen for the trees in the double-furrow preparation than in the other four preparations tested.

Soil moisture samples taken during the first 3 years of the study showed that the lowest levels of moisture were associated with the double-furrow preparation, where the trees grew best.

Trees planted on the "lay" of overturned double furrows were taller after 5 years than trees planted in: (1) the bottoms of single furrows; (2) in rips that penetrated the soil to an average depth of 28 inches; (3) in 2-foot-square scalps; and (4) in non-prepared ground.

Trees planted by machine methods were taller after 5 years than trees planted by hand using bars and mattocks when soil differences between methods were considered. If present trends in growth rates continue it is possible that the trees in the double-furrow treatment will have a growth advantage of practical value over the trees in the other preparations.

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